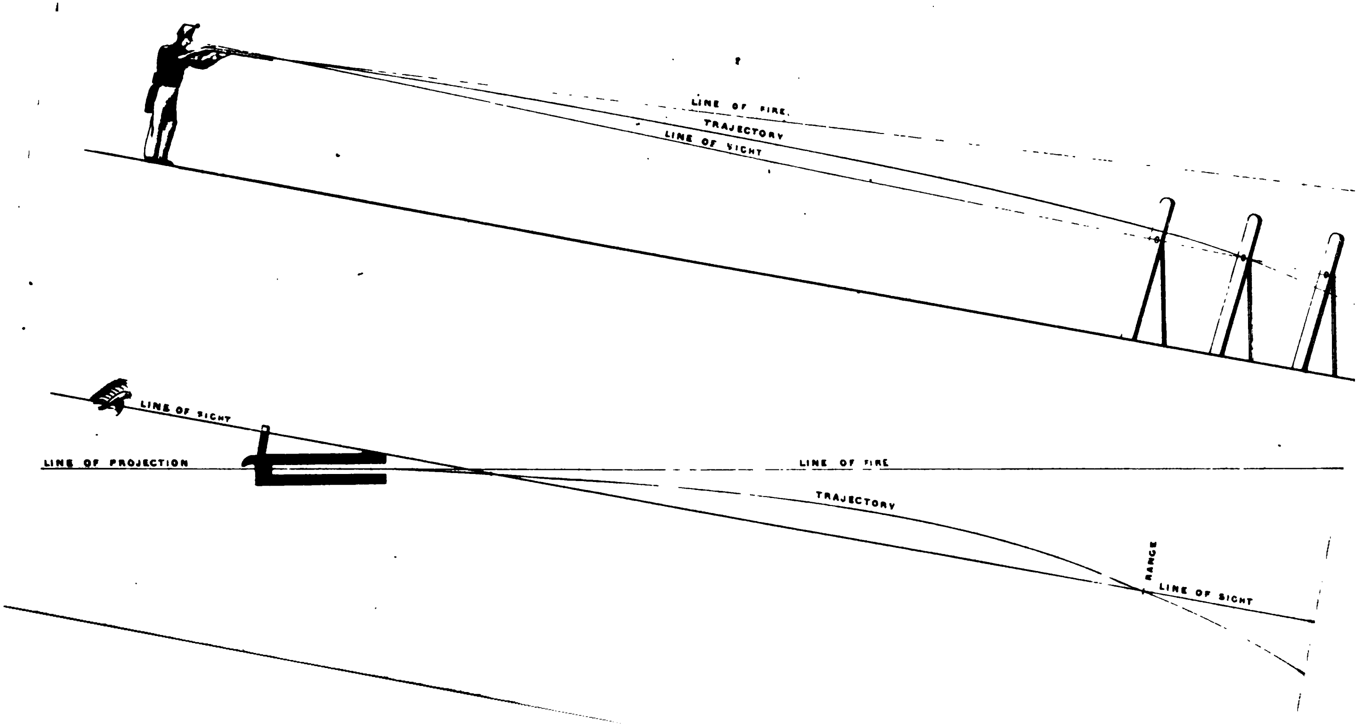
KENNEDY

1858

THEORY OF MUSKETRY.



LINE OF FIRE.
TRAJECTORY
LINE OF SIGHT
LINE OF SIGHT
LINE OF PROJECTION
LINE OF FIRE
TRAJECTORY
RANGE
LINE OF SIGHT

THE
THEORY OF MUSKETRY,
ADAPTED FOR THE
USE OF THE TROOPS.

BY

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1855.

INTRODUCTION.

The following course of Instruction in the Theory of Musketry, was arranged for the use of the School of Musketry, at Hythe; and a trial of several months has proved its utility as a means of instruction.

It is published with the view of facilitating the labours of the Officers, and Non-commissioned Officers, Instructors of Regiments and Depôts.

The great aim has been simplicity, and to express in plain language, so much of the Theory of Musketry, as is absolutely essential to be known by the Soldier, before he can be held to understand, the proper use of the perfect weapon, with which he is now armed. The Theory of Musketry is, however, the same for all fire-arms; and the following pages are equally applicable to the smooth-bore musket, (as far as its power goes), the line, or the sea-service Minié rifle, the Ordnance carbine, or the last new rifle musket.

In teaching the theory, I should recommend Instructors to use a black board, of any convenient size, with a movable section of a musket attached, such as that in Diagram 6, made either of pasteboard, tin, sheet-iron, &c.; and the position of the various lines, marked by means of a chalked string, held in the required direction across the board, which will leave a white line, when drawn up by the middle, and suddenly let go. The curved lines, must of course be drawn by hand.

Each Section will take from ten to fifteen minutes' to explain; and I cannot too strongly urge, the system of teaching, by means of question and answer, in small squads, of ten or a dozen men. The Instructor should satisfy himself, by means of the men's answers, that the Section has been thoroughly understood, before the men are dismissed; and should commence each succeeding Section, by questioning the men, on the subject of the previous lesson.

It is not intended, that the illustrations introduced into the following pages, should always be used. Many others, will doubtless suggest themselves, to an Instructor; and if one does not seem to be understood, try another. The more familiar an illustration is, the easier will the point, to explain which it is used, be understood. Above all, let me recommend patience and perseverance; remember, that to an uneducated man, you may be offering ideas, which, though simple, are strange and new; therefore, give time, and be not vexed or disappointed, if what is so clear to you, should not at once be understood.

It is intended, when time and opportunity allows, to publish two or more additional parts, for the use of Officers, and those Non-commissioned Officers and Soldiers, who may be better educated than their comrades.

J. C. K.

SCHOOL OF MUSKETRY,
HYTHE,
DECEMBER 2ND, 1854.

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IN

MUSKETRY.

Section I.

The meaning of the terms, a straight line, a curve, and a circle, is so well known, as to need no explanation; but it is also necessary, clearly to understand, what are lines parallel, and what is an angle.

Parallel Lines.

Straight lines are called parallel, when placed at the same distance from each other, keeping so throughout their length, neither coming nearer, nor separating further.

Fig. 1.

A————————B For instance, the lines A B and C D
C————————D being equally distant, are parallel to each other. It is plain, that however far you draw or continue these straight lines, they never can meet, for they will always be at the same distance from each other, whether they are an inch or a mile, or ten, or a hundred, or any number of miles long.

Lines not parallel must meet.

Any two lines, not parallel, must meet, if continued far enough, for not being at the same distance from each other, one must slope towards the other, and, however slight the slope may be, must at last meet, as A B and C D do at E.

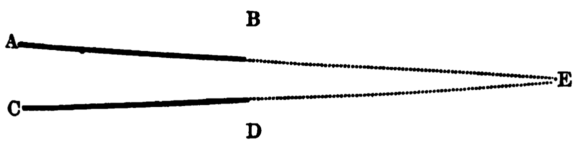
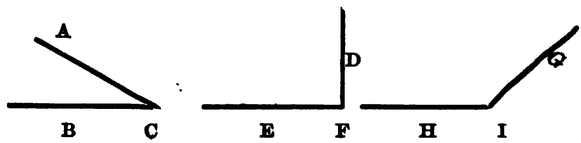


Fig. 2.

Angles. Two straight lines meeting, form an angle, at the point where they join. Thus, the lines A and B meeting at C; D and E meeting at F; and G and H meeting at I; all form angles of different sizes.

Fig. 3.



Construction of the barrel. The first point for consideration in the Theory of Musketry, is the construction of the barrel, from which the bullet is fired. In order to make the theory as simple as possible, we will leave out of the question for the present, the grooves of the rifle musket, and consider the barrel as a smooth bore, as it really is before the grooves are cut, which is almost the last process in its manufacture.

The Bore. The inside, or bore of the barrel, is a perfect hollow cylinder.

A Cylinder. A cylinder, is a long round body, which may be described, as formed of circles, all of the same size, placed one above the other, so that the centre of each, is exactly over the centre of the circle beneath, and under the centre of the circle above. For instance, a pile of shillings, forms a cylinder. A common round ruler is another example; for, were it cut across into slices, they would be found to be circles, all exactly the same size. The line passing lengthways through the centre of a cylinder, is called its axis. The difference between a solid and a hollow cylinder, is, that whilst the former is represented by a long round body, like a ruler, the latter is the hollow, left in a lump of soft clay, into which the ruler had been thrust, and withdrawn.

Outer form of the barrel. The outside of the barrel, although also long and round, differs materially in form from the inside; for instead of being of the same dimensions from end to end, like the hollow cylinder of the bore, it is larger at

the breech than at the muzzle, to which it gradually tapers.

It is thus constructed, because a certain thickness is required at the breech, to withstand the great force of the charge of gunpowder, when first fired, and it tapers away to the muzzle, where the same strength is not wanted, in order to render the musket as light as is consistent with safety, and with sufficient strength to carry the bayonet fixed. One end being thicker than the other, it is evident, that the surface of the barrel, is not parallel to the bore, therefore the two lines continued onwards, must meet and form an angle. This is an important point, which must not be forgotten, as it will be referred to again.

The form of the barrel, both inside and out, being ascertained, we come to the "axis of the piece," an imaginary line, drawn through the centre of the bore, and parallel to its sides. Were a perfectly straight thin wire placed in the bore, so that it extended from the centre of the breech, to the centre of the muzzle, being equally distant from the sides of the bore, from end to end, such wire would represent the axis of the piece. Axis of the piece.

The continuation of the axis in a straight line, is called the "line of fire," because it marks the direction of the bullet, at the instant it leaves the muzzle, and in which direction the bullet would naturally fly, were there no other force, besides that of gunpowder, acting upon it. Line of Fire.

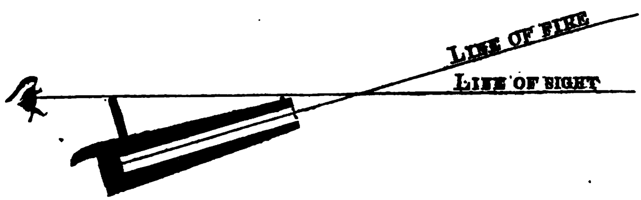
You will naturally ask, what other force can act upon it? and why does not the ball move onwards in a straight line, after issuing from the musket, that is, in the "line of fire?" I will only tell you for the present, that certain forces do act upon the bullet, and that it cannot move in the line of fire. These forces, and the manner in which they act, will be explained hereafter.

The next line to be considered, is that by which aim is taken, or the "line of sight," which is drawn from the eye, through the centre of the notch of the back Line of Sight.

sight, and across the tip of the foresight, to the object aimed at. Were there no sights placed upon a musket, the line from the eye, looking along the outer and upper surface of the barrel, continued to the object, would be the line of sight.

The barrel, being of necessity, thicker at the breech, is larger there, than at the muzzle, it is evident, that the "line of sight," taken along the surface of the barrel, or at any height whatever of the back sight, cannot be parallel to the "axis of the piece," but must incline towards it, so that it crosses and forms an angle with the line of fire, (the continuation of the axis) a short distance beyond the muzzle. See Fig. 4.

Fig. 4.



SECTION II.

THE line of sight and the line of fire, having now been laid down, and the direction taken by each of them clearly understood, "the trajectory," or actual course in which the ball moves during its flight, remains to be described.

A bullet having left the muzzle of a musket, is acted upon by three forces in different directions. The Trajectory, or actual course of the ball.

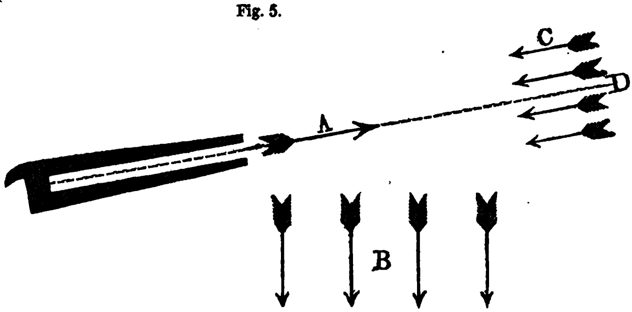
1st. The force of the charge of gunpowder, fired behind the ball, endeavours to drive it onwards in a straight line.

2nd. The force of gravity, draws or attracts it towards the earth.

3rd. The resistance which the air offers to the passage of the ball, trying, as it were, to push it back, that is, acting in the direction exactly opposite to that in which the ball is moving.

Let us examine in turn, the effect of each of these forces.

Fig. 5.



1st. The bullet acted upon by the exploded gunpowder alone, would naturally be driven onwards in a straight line; the ball being confined by the sides of the bore, whilst moving up the barrel, the centre of the Action of the charge of gunpowder.

bore or axis, and the line of fire its continuation, must be this straight line, (A D Fig. 5,) in which it would continue to move for ever, with the same speed that it had, when leaving the musket. This of course it cannot do, for gravity, and the resistance of the air, also act upon the bullet, and greatly affect its flight.

Gravity.

2nd. The force of gravity, which draws the ball downwards. Gravity, is the natural power by which all things fall, or are drawn towards the earth.

For instance, I hold a bullet between my finger and thumb, I open them gently, taking care not to give the slightest push or motion to the ball,—it is left to itself in the air,—I gave it no motion, it has no power in itself to move,—yet it did move, and fell to the ground, acted upon by the force of gravity, drawing or attracting it to the earth.

Gravity can only act in one direction, that is, straight downwards, as represented by the arrows marked B in Fig. 5. The instant the ball leaves the muzzle of the piece, and during its whole flight, this force is acting upon it, drawing or attracting it towards the earth.

Resistance of the air.

3rd. The resistance of the air or atmosphere.

It may seem strange, or even untrue, to many who may not have thought about it, or to those who perhaps have never heard of it before, that the air which surrounds us, which we breathe, and in which we move, can possibly offer any resistance, to the passage of so hard and heavy a substance, as a leaden bullet. Yet it is so, and can easily be proved.

Let us take some familiar examples, of the resistance of the air.

Open a book, and hold it in such a manner, that a page or two will be upright, whilst the book is kept still: move it rapidly across, from one side to the other, and you will find, that the air, opposing the passage of the leaves, forces them backwards to the right, if the book was moved from right to left; reverse the motion, and they will be forced to the left. The quicker the

book moves, with the greater force, will the leaves be thrown back.

Take a sheet of pasteboard, and pass it quickly through the air edgeways, the air having so small a surface as the edge, to act upon, the resistance will hardly be felt, but hold it so that the flat surface of the pasteboard should lead, and the resistance of the air will be found very considerable.

We observe a man walking upon a still calm day, not a breath of wind is stirring, he is moving slowly, and although the air is resisting his passage, yet the resistance is so slight, that it is not felt. He begins to run, immediately he feels the air on his face, and the resistance is now sufficient, to cause the ends of his handkerchief and hair, to stream in the contrary direction, to that in which he is proceeding. Mounting a horse, he gallops onwards, he feels the pressure of the air stronger in his face, his coat tails fly to the rear, and you see him fix his hat firmly upon his head, because he fears that the resistance of the air will force it off. Arrived at the railway station, he starts by an express train; the day remaining calm and still, he puts his head out of the carriage window, there is no wind to blow off his hat, but in an instant it is gone, and the pressure upon his face, from the resistance of the air, is so great, that he draws in his head, rather faster than he put it out.

The quicker the motion of a body, the greater the resistance.

From these examples we learn, not only that air does offer resistance to moving bodies, but also, that the faster the body moves, the greater the resistance becomes; for when walking, running, galloping, or in the express train, the state of the air was the same; whilst the effects of its resistance increased, when the speed of the moving body increased.

Result of the resistance of the air.

Now the speed of a train is trifling, when compared with the flight of a musket bullet, therefore the resistance of the air to the passage of a ball, must be very great. It acts in direct opposition to the course of the ball, and in Fig. 5 the arrows marked O, show the direction in

which it acts. The result of the resistance is, that it checks the speed of the ball, and at last, overcoming the force that set it in motion, the bullet ceases to move onward, and touches the ground.

The trajectory, or course of the ball.

Now that we understand the manner in which the three forces act upon the ball, it is easy to describe its course. If acted upon by gunpowder alone, the ball would fly straight onwards in the line of fire, but the instant it leaves the muzzle of the musket, gravity commences to draw it downwards. Therefore it cannot travel in the line of fire, because gravity attracts it to the earth; it cannot yield to the force of gravity altogether, and fall straight to the ground, because the force of the gunpowder is driving it on. It is therefore clear, that the ball, moving onwards and downwards at the same time, must travel in a curve, below the line of fire, from which it must fall off more and more, until at last it falls to the ground.

Increase of the curve as the ball flies onwards.

The resistance of the air, by causing the ball to move slower and slower, greatly affects the degree and length of this curve. The slower the ball travels, the longer time has the force of gravity to act upon it; therefore, as the onward motion decreases in speed, the effect of gravity increases, and the greater becomes the curve described by the bullet.

The force of gravity, acting more powerfully as the bullet nears the earth, also increases the curve.

This curved line, the actual course of the ball, is called the "trajectory."

See Fig. 6 and the Frontispiece.

Section III.

How to use the three lines so that the ball will strike any given object.

Being thoroughly acquainted with the lines of sight, of fire, and the trajectory, described in the preceding sections, we have now to consider, the most important point in the Theory of Musketry, viz., how to use these three lines, so that a ball when fired, should strike a given object, at any given distance, within the range of the piece.

Let the mark be the centre of a target, placed at the distance of 100 yards, and the bull's eye or centre, the same height, from the ground, that the musket is, when held at a man's shoulder, on an average, about 4 feet 6 inches. Hold the musket, so that the muzzle is placed exactly opposite to, and the axis of the bore level with the bull's eye. (In Fig 6 the movable section of a musket, attached to the diagram, can be so placed.) When in this position, the line of fire would pass through the mark, but would the ball hit it? Certainly not; for we know that the bullet, acted upon by gravity, and the resistance of the air, cannot keep in the line of fire, but falls gradually below it, and would therefore strike below, or pass under the mark.

Careful trials have measured the degree of curve of the trajectory, and prove by actual practice, that when a bullet, fired from the rifle musket, has travelled 100 yards, it has dropped about 1 foot 5 inches; therefore, the ball fired from the rifle musket, held as described, would strike the target, just 1 foot 5 inches below the bull's eye.

In order then to hit the mark, it is evident, that the axis of the piece must be so raised, that its continuation—the line of fire—will, at the distance of 100 yards, pass 1 foot 5 inches above the bull's eye. That being done, the ball during its flight of 100 yards, will fall 1 foot 5 inches below the line of fire, and the bull's

eye will be struck. (Place the musket in Fig. 6, so that it corresponds with the dotted lines, and the effect of the increased elevation, given to the axis of the piece, will be seen at a glance.)

General Rule.

It is sufficiently near the truth for practice, to say, that, whatsoever the distance may be, the line of fire should be made to pass just as far above the object, as the ball will drop below the line of fire, during the time of its flight from the musket, to the object fired at.

How the proper elevation is given to the musket.

The question now is, by what means do we give exactly the proper elevation to the musket, so that the line of fire passes the required height above the mark? The proper elevation is given, by the back sight, and its sliding bar. The block sight or lowest notch on the back sight, being calculated for a range of 100 yards, is such a height above the axis of the piece, that when the object aimed at, is seen through it, the foresight of necessity must be raised, to bring it into the same line, with the notch of the back sight and the mark. The fore sight being raised, elevates the muzzle, the axis, and of course its continuation—the line of fire—which passes the required distance of 1 foot 5 inches above the object, whilst the line of sight is directed straight upon the mark from the eye, through the back sight, and across the tip of the fore sight.

By raising the sliding bar, increased height above the axis of the piece, is given to the back sight.

For every longer range or increased distance, a greater height is given to the back sight, in order to raise the line of fire more and more above the object, and allow for the drop of the ball, which increases with the distance. The fore sight being unalterable in size, and fixed near the muzzle, it is plain that the higher the sliding bar of the back sight is, the higher must the muzzle of the piece be raised, to bring the foresight into line with the back sight and object aimed at, so as to form the line of sight, by which aim is taken.

As the principle is the same, for the sights at all

distances, as at a hundred yards, it is not necessary to take up space here, by going over every successive distance, but bear in mind the simple rule, "that the greater the distance is, at which you are about to fire, the greater must be the elevation given, to the axis of the piece."

The back sight marked to the various ranges.

In order to save the time and trouble it would take, and prevent the constant mistakes which would be made, were each man left to find out the proper elevation for himself, the back sights of the rifle muskets, are cut with lines, numbered from 1 to 900 yards, each line giving the proper elevation, for the range denoted by the number.

Explanation of Fig. 6.

(In Fig. 6, it was not thought advisable, to show more than the direction of the various lines, when the musket is fired with its bore opposite to, and its axis level with, the object, and when the 100 yards sight is used; but by adding a strip of paper to the cardboard, bull's eyes may be made, representing 200, 300 yards, &c., &c., and then raising the back sight, which is movable, the lines of sight, of fire, and the trajectory, may be put in with a pencil. Fig. 6 is intended only to show the principle, and is not constructed upon any scale of proportion.)

Let us now examine the relative positions of the lines of sight, fire, and the trajectory.

In Section I, we learnt that the line of sight crosses the line of fire, a short distance from the muzzle, as in Fig. 6 at A. What this distance is, depends upon the elevation given to the musket, the greater the elevation, the nearer to the muzzle does the line of sight cross the line of Fire.

The trajectory crosses the line of sight twice.

The trajectory being a curve always below the line of fire, crosses the line of sight a little further on, gradually rising above it, until falling off more and more from the line of fire, it again approaches the line of sight, crossing it for the second time, before reaching the ground.

Aim is taken, by the line of sight being directed

The second intersection of the line of sight by the trajectory. upon the mark, consequently the object must be in the line of sight. The ball in its course, only touches the line of sight twice, first, when it crosses it near the muzzle, and a second time, at a greater distance; it is therefore evident, that unless the trajectory crosses the line of sight for the second time at the object fired at, the mark will not be hit. The height of the back sight is such, (supposing no fault to exist in the construction of the sight) that the proper elevation is given to the axis of the piece, to cause the trajectory to cross the line of sight for the second time, exactly at the distance of the length of range, marked upon the sight, as in Fig. 6, where the dotted lines cross at the bull's eye, when the 100 yards' sight is used.

The trajectory and line of fire may be considered the same for a short distance. Owing to the great speed with which a bullet moves upon first leaving the musket, gravity has so short a time to act upon it, during the commencement of its flight, drawing the ball so little below the line of fire, that the trajectory, during the first part of its course, is scarcely distinguishable from it, and practically, the two lines may be considered the same for a short distance, after which, the speed of the ball being checked by the resistance of the air, it falls off more and more from the line of fire.

Point blank. The point blank range of any musket, is the distance to which it will throw the ball, before it touches the ground; the piece being held with its axis parallel to the ground, and 4 feet 6 inches above it. When the Minié rifle musket is fired in this position, (Fig. 6) the first graze is about 177 yards, which distance is the point blank range of the arm. Every different description of musket, will of course, have a point blank range of its own, ascertained in the same manner.

Fig. 6 also shows the increase of the curve of the trajectory. The ball in passing 100 yards, from the muzzle to C, falls 1 foot 5 inches; in the succeeding 77 yards, from C to D, it falls 3 feet 1 inch.

Section IV.

In order to obtain accuracy of fire, it is not sufficient alone, to direct the line of sight upon the object, however carefully it may be done, but in addition, it is absolutely necessary, that the musket should be so held whilst firing, that the back sight may be perfectly upright. Should the sight be inclined to the right, the ball will go to the right of the mark; if to the left, it will strike to the left; and the longer the range, the more will the distance that the ball will fly wide of the object, increase.

Accuracy of fire depends upon the back sight being kept upright.

To explain why it is so, we must in the first place describe and understand, what are horizontal and vertical planes.

A horizontal plane, is any perfectly flat surface level with the earth, such as the floor of a room, the top of a table, &c. The surface of water when at rest, is always a horizontal plane.

Horizontal Plane.

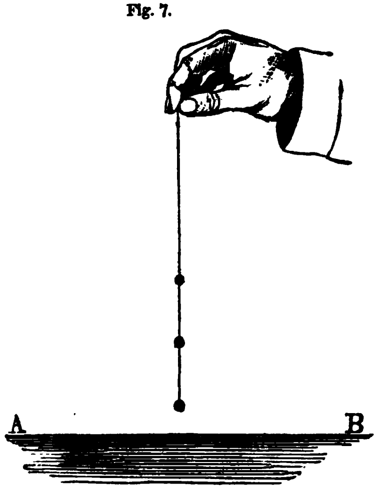
A vertical plane rises straight upwards from the earth, neither leaning to one side nor to the other, such as the wall of a house, or the side of a room.

Vertical Plane.

String three bullets on a piece of thread, and let

Example of the above.

Fig. 7.



them hang in the air, over the surface of still water, as in Fig. 7, and we have a perfect example of a horizontal and a vertical plane. The surface of the water being the former, whilst the thread represents the latter, and the three bullets being exactly over each other, are all three, in one and the same vertical plane.

The lines of sight, fire, and the trajectory must be kept in the same vertical plane.

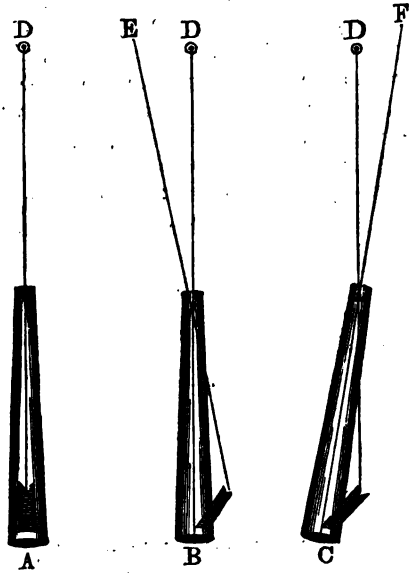
When firing, the line of sight, the line of fire, and the trajectory, must be kept in the same vertical plane. The two latter are always in the same vertical plane; for we have already learnt, that the trajectory is formed by the force of gravity and the resistance of the air acting upon the bullet, and causing it to move in a curved line, directly underneath the line of fire, and exactly below which it always remains, whatever may be the direction given to the line of fire.

The line of sight, however, is only in the same vertical plane with the line of fire and the trajectory, when the musket is held with the back sight perfectly upright; the slightest inclination to either hand, throws it out of the vertical plane, and the ball will strike according to the inclination given to the sight, more or less wide of the mark, to whichever side the sight was inclined.

The sight being inclined to the right, that the ball goes to the right proved.

To prove that this is the case, take the breech pin out of a musket, place the barrel on a stand or sand bag rest, and looking through it, make a spot on the wall, to show, that although the barrel may be turned upon its axis, the direction of the line of fire will remain the same. Raise the back sight to its full height, keeping it perfectly upright, and also mark the wall at the point upon which the line of sight falls, as in Fig. 8, A, where the line of sight is directed upon D, which will be found to be in the same vertical plane with the mark first made on the wall, and seen, when looking through the bore, along the line of fire. Incline the sight to the right, as in Fig. 8, B, taking care not to move the barrel to either hand, but turning it on its axis, (prove this by looking through the bore, and seeing that the line of fire remains directed upon the mark first made,)

Fig. 8.



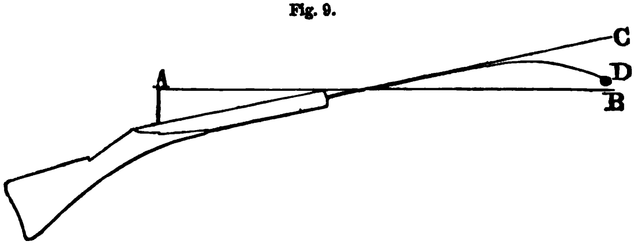
now take the line of sight and, it will be found to pass towards E, considerably to the left of the point D, which it covered before. Aim is taken by the line of sight, therefore a man, who through ignorance or inattention, fires with his sight inclined as in B, would aim at the mark D, by directing his line of sight straight upon it, as in Fig. 8, C. What would be the result? In bringing the line of sight from E to D, the barrel is carried slanting to the right, and the line of fire is directed upon F, just as much to the right of the mark D, as the line of sight was to the left, when the barrel was in the position marked B. The trajectory being always under the line of fire, of course goes with it, and the ball from a musket aimed at the mark D, with its sight inclined to the right, as in C, would miss the mark, and pass to the right of it, as at F.

This method may seem complicated as written down, but it is perfectly simple, when tried practically.

It equally answers the purpose of instruction, to place the musket, in the first instance, with its sight inclined to one side; then take the Line of Sight, and mark where it falls; then look through the bore, and see where the Line of Fire, and consequently the Trajectory, would go.

There is another way by means of a model, (which any regimental armourer can make,) of showing the

Fig. 9.

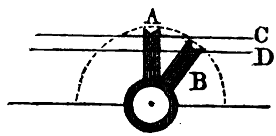


effect of not keeping the sight upright, Fig. 9 represents a small wooden model of a musket, a couple of feet or so in length, a stout wire is bent and fixed as A B, to form the line of sight; place another firmly in the muzzle, to represent the line of fire as C; form also of wire, the trajectory D, insert it into the muzzle, under the line of fire, but so loosely, that with the support of a wire link suspending it from the line of fire, it moves freely from side to side, so that it always hangs directly under the line of fire. Cause each man under instruction, to aim along the line of sight, at a wafer, or mark, upon the wall, with the back sight A perfectly upright, then let the sight be inclined to either hand, keeping the line of sight direct upon the object, and the line of fire and trajectory will be seen going more and more to the right, as the sight is inclined to the right, or to the left, if inclined to the left.

There are other methods, which it would be tedious

to describe, by which an instructor, can show and prove this important point.

Fig. 10.



In addition to throwing the ball to the right or left, the inclination of the sight affects the range, by lowering the elevation. Fig. 10 represents the cross section of a musket with its back sight: The back sight when raised gives the proper degree of elevation for 900 yards, when held upright, as at A; incline it to the right, as at B, and it is evident, that although aim is taken with the 900 yards sight, the elevation is lowered, by exactly the distance of CD. The ball would therefore not only fly to the right, but would strike low or fall short, from want of sufficient elevation. The more the sight is inclined, the greater will be the loss of elevation, which a glance at Fig. 10, will plainly show.

Elevation given to a musket is lowered by the sight being inclined to either hand.

As the length of range increases, more care, if possible, must be taken, than at shorter distances, to keep the sight upright; for a trifling inclination to either hand, when firing at the longer distances, will throw the ball very wide of the mark.

Section V.

Various causes which affect the course of a ball.

There are several causes which affect the course of a ball, after it has left the musket; and a soldier, ignorant of what they are, is surprised to find, that in spite of the care and steadiness with which he may have aimed, he has missed the mark.

Wind blowing up, down, or across the range.

The first of these to be taken into consideration, is the action of the wind. In Section II. the resistance offered by the air, to the passage of a ball, was proved and described. Now wind, is merely air in motion, and when blowing from the rear whilst firing, is moving in the same direction as the bullet; the resistance the air offers is consequently less, the ball flies with greater speed than on a calm day, gravity has less time to act upon it, its range is slightly increased, and it either strikes high, or passes over the mark.

Wind from the front, has exactly the contrary effect, the air is in motion, and moving in opposition to the course of the ball, the resistance is therefore increased, the bullet travels slower, the force of gravity has a longer time to act upon it, the curve of the trajectory is greater, the range is rather less, and the object fired at, is either struck low, or not reached.

When blowing across the range from right or left, the wind drives the ball to the opposite side, causing it to pass to the left of the target, when from the right, and to the right, when from the left.

An allowance must therefore be made, for the wind when firing. With the wind from the front, aim a little high; when from the rear a little low; or take your sight slightly fuller or finer. When blowing from the right, aim to the right; when from the left, to the left; remembering that wind across the range,

has a much greater effect upon the ball, than when from the front or rear.

Should the wind blow from any other direction than straight up, or down, or across, a proportionate allowance must be made; for instance, suppose it to be from the right front, aim should be taken a trifle higher, and somewhat to the right; about half as much either way, as if it had blown direct from the front, or across from the right.

The longer the range the more allowance must be made.

The greater the distance of the object, the greater must be the allowance made, for the further the ball has to fly, the longer time will the wind have to act upon it, and the further will it be driven from its proper course.

State of the atmosphere.

The flight of a ball is also, in some little degree affected, by the state of the atmosphere. When the weather is damp or foggy, the air being full of moisture, is thicker, and offers greater resistance, a slight increase of elevation is therefore necessary. In very dry warm weather, the air being thinner, the resistance is not so great as it usually is, and the ball flying rather faster, would strike a little high, therefore the sight should be taken finer than when firing in average weather.

No allowance need be made in practice, for the state of the atmosphere, except in extreme cases, and only then, when firing at long ranges.

Sun.

The sun shining upon one side of the foresight, and upon the opposite side of the notch of the back sight, is apt to deceive in taking aim; for when the sun is on the right, the foresight appears more to the right, and the centre of the notch of the back sight more to the left, than they really are; the line of sight then taken through and across the sights, will cause the line of fire, and consequently the trajectory, to pass to the left; therefore it is necessary, to make a slight allowance to the right, when the sun is on the right, and to the left, when shining on the left.

Effect of the difference of level when firing upwards or downwards.

A bullet fired from below, at an object on a height above, requires also a slight allowance to be made, should the difference in height, and the length of range, be considerable. Firing, for instance, up a precipice when forcing a mountain pass, or from a boat to the summit of a lofty cliff, it would be necessary to give a slight increase of elevation, for the ball driven upwards by the charge of gunpowder, would be more directly opposed to the force of gravity, than when flying across a level; the speed of the ball would be checked, and it would strike low. Therefore, when firing upwards at a long range, aim a little high.

Firing downwards from a height, the contrary takes place, gravity is drawing the ball to the earth, and the gunpowder is also driving it downwards; the two forces are acting together, and the speed of the ball being thereby increased, aim must be taken rather low, or a trifle on this side of the object.

At short distances, no allowance whatever need be made, for the force of gravity acting either with, or against, the force of the gunpowder.

Exact rules as to the allowance to be made impossible to be laid down.

With regard to this section, it is impossible to lay down more exact rules than those above. Each man must form his own rules, as to what allowance should be made for the wind, air, sun, and difference of level, and careful observation whilst at ball practice, will enable him to form them for himself with ease.

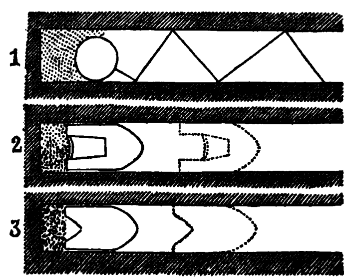
Section VI.

It is of importance, that the ball, with which any musket is to be loaded, should be smaller in size than the bore of the piece, in order that the musket may be loaded, and reloaded, with ease and rapidity. This difference in size, leaves a space between the ball and the sides of the bore, which is called "windage." To diminish the windage, or to do away with it altogether, without making the bullet fit so tight as to render it difficult to load with, has been the great aim of all the late improvements and alterations both in fire-arms, and ammunition. Windage.

The result of these improvements is seen, in the last new pattern rifle musket, as yet the most perfect weapon, that has ever been placed in the hands of a soldier in any country. New pattern Rifle Musket.

One of the principal causes of the inefficiency of the old smooth-bore regulation musket, was windage; we will therefore examine, first how it affected the flight of the round ball when fired from the old musket, and then show how this defect is remedied, in the new rifle musket. Old smooth-bore musket.

Fig. 12.



Cause of its inefficiency.

Fig. 12, No. 1, is a section of an old musket loaded with a round ball, which, by its own weight would rest upon the bottom of the bore, when the piece was held at the "present," and being smaller than the bore, there would be windage, or a certain space left above the ball.

Gunpowder when fired, acts with equal power in all directions, and when confined, (as in the barrel of a musket) forces its way wherever there is the least opposition offered. In this case, therefore, a portion of the force of the charge escapes by the open space above the ball, whilst the force of the remainder of the charge, drives the ball onwards. The greater the windage, the greater is the escape and waste of the force of the charge, a matter serious enough in itself, but only a part of the evil effects of windage; for gunpowder acting equally in all directions, presses the ball violently downwards, as it escapes through the space above, and the ball, driven forwards by part of the charge, and downwards by the other part, would strike the bottom of the bore, from whence, following nearly the same law, by which a ball would bound off, when thrown against a wall, the bullet would pass along the bore, bounding and rebounding irregularly from top to bottom, as represented by the zig-zag lines in Fig. 12, No. 1, the direction in which the ball would go, depending in a great measure upon the part of the barrel last struck, as it left the muzzle. For instance, should it have made its last bound from the lower part of the bore, the ball would go high; if from the upper, the same cause would send the ball low. The bullet, however, does not always rest evenly upon the bottom of the bore; an uneven or extra fold of cartridge paper, grains of gunpowder, or a cake of fouling, would cause it to lean to one side or the other; then the ball would bound from side to side, and striking the right side of the muzzle last, would fly off to the left, or if the left

Bounding motion of the round ball in the Barrel.

Irregular flight after leaving the muzzle.

of the bore was last touched, it would fly off, to the right of its proper course: in fact, owing to the windage, the motion of the ball in the bore would be so irregular, that no amount of experience from preceding shots could be of use, in judging what part of the bore would be struck last, by the next shot. No allowance could therefore be made, to correct the error arising from it, and except at short ranges, chance, not the skill of the marksman, ruled where the ball was to fly, sometimes to the mark, generally wide of it, in all directions.

Let us now load with the Minié bullet, as in No. 2, Fig. 12. In form a cylinder, ending in a rounded point, the bullet fits the bore more closely than the round ball, but not so tightly, as to make the loading difficult; to assist which, the bullet end of the cartridge is dipt in grease. There is still, however, some little windage to be got rid of, and this is managed, by means of a deep hollow in the cylinder of the bullet, which sloping upwards, is smaller near the centre of the bullet, than at the bottom, in which is placed an iron cup. This cup, acted upon by the force of the gunpowder, is driven violently up the hollow; the unyielding iron driven upwards, acts as a wedge, and the softer metal, lead, giving to the pressure, is forced outwards, increasing the size of the bullet, so that the bore is filled by its expansion, and all windage completely destroyed. The bullet, which wrapped in greased paper, loaded with ease, is so increased in size, that having been once fired, the musket could not be reloaded with the same ball a second time, unless great force were used to drive it down. The iron cup, however, is not only troublesome and expensive to manufacture, but is at times, the cause of wild shooting, from the carelessness of the boys employed in making up the cartridges, not placing the cup evenly, in the hollow of the bullet. When this is the case, the cup is driven up slantingly, and the bullet is either imperfectly, or not sufficiently expanded, so as to exactly fill the bore. Minié Bullet.

The new or Pritchett Bullet. A bullet of smaller diameter has, therefore, been adopted by Government, in which the expansion or swelling is obtained by the direct action of the gunpowder upon the hollow at the base of the bullet, which is made of a different shape, as in No. 3, Fig. 12; the lead yields to the force of the charge, the bullet expands, and the same result, or nearly so, is obtained, as when the iron cup is used.

In Nos. 2 and 3, the effect of the gunpowder upon the bullets, is shown, by the dotted lines, representing the bullets, as when passing up the barrels.

When there is no windage a smaller charge may be used. Windage being done away with, it is evident that the charge may be reduced, for there being no vacant space, by which the force of the gunpowder can escape, every grain of the charge is used, none being wasted, as with the round ball, which only weighing 488 grains, was fired with 4½ drams of gunpowder; whilst the Minié bullets of 680 grains, only require 2½ drams.

Rifling. We have hitherto considered the musket as a smooth bore, in order the better to explain the theory of musketry, but we will now enter upon the question of rifling. A musket is made into a rifle, by a number of spiral grooves being cut into the sides of the bore.

Grooves. There is no certain number, but three being considered (for reasons which need not here be given) the best, the last new pattern musket is made with that number of grooves, the Minié having four. In both muskets, the grooves are cut, so that each takes a twist of a half turn in the length of the barrel, which being 3 ft. 3 in., gives an entire turn in 6 feet 6 in. The grooves are at an equal distance from each other, of an even depth, and of the same degree of twist from end to end, which is easily proved by looking through the barrel, with the breech pin out, first through one end, and then through the other.

The effect upon the ball of the barrel being grooved. The long shaped bullets of both kinds, we have found expand, when the charge is fired, so as to fill the entire space of the bore, consequently the soft lead is forced into these grooves. The grooves having the twist of a

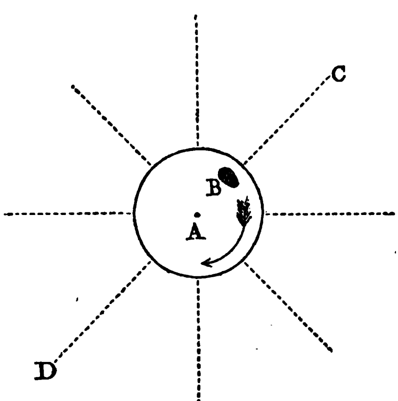
half turn, the bullet now fitting them tightly, must follow this twist whilst moving up the barrel, thereby getting a spiral motion, which is continued to the bullet after leaving the musket; and it flies through the air, point foremost, spinning round and round upon its axis, which is the line drawn lengthways through its centre.

The advantage arising from its thus spinning, is, that it overcomes an irregular whirling motion, which most bullets fired from a smooth bore have, whilst passing through the air, and which causes the ball to fly out of its true course, sometimes one way, sometimes the other. This motion is in a great degree caused, by some portion of the ball, not its centre, being heavier than other parts, which is generally the case, and even with the care now taken in making bullets by the most beautiful machinery, the heaviest part of the greater number of musket bullets, will not be exactly their centre.

A ball having its heaviest part not in the centre cannot fly true.

A ball of this description, will invariably fly out of its true course, in the direction in which the heaviest part lay, when leaving the muzzle. For instance,

Fig. 13.



in Fig. 13, let A be the real centre of a ball, and the spot B its heaviest part, leaving the muzzle of a smooth bore, as now placed in the Fig. The bullet would fly off towards the direction C, and go wide of its proper course.

How rifling increases the accuracy of fire.

Let this same ball, with its heaviest part in the same position, leave the muzzle of a rifle. The spiral grooves would cause the ball to spin upon its centre A, and carry the heaviest part B, round and round, as shown by the arrow. Upon leaving the muzzle, the bullet would strive to go off towards C, but before it could do so, the spinning motion would have brought the heaviest part, B, to the opposite side, where it would fly off towards D, which it could not do, because it immediately was back at C, and so on, never able to fly out of its proper course, for before it could yield in one direction, it would be trying to be off in another.

It is therefore plain, that a ball fired from a rifle, must fly with greater accuracy than from a smooth bore, for the spinning motion given to the ball by the spiral grooves, prevents, as long as it lasts, any inclination which the ball, owing to irregularity of shape or weight, may have, to fly out of its proper course.

In the foregoing Sections, there are many points in the Theory of Musketry, which have been either omitted altogether, or very slightly touched upon, but the intention has been, to give all those that are actually necessary to be known by a soldier, in order that he may understand his weapon, and use it in a proper manner; not only because he has been so taught at drill, but also because he understands the principles upon which he fires, and can give correct reasons, why in one instance, the mark was missed, and in another hit.

THE END.